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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 2, 2019/2020

### EEL4106 – HIGH VOLTAGE ENGINEERING (LE)

2 MARCH 2020  
2:30 p.m – 4:30 p.m  
(2 Hours)

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#### INSTRUCTIONS TO STUDENT

1. This question paper consists of 4 pages including the cover page with 4 Questions only.
2. Answer ALL questions. The distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

**Question 1**

- (a) Complete Table Q1 which describes the definition of high voltage as per IEC 60038. [3 marks]

Table Q1

| IEC 60038<br>voltage range | AC rms voltage<br>(V) | DC voltage (V) | Defining risk |
|----------------------------|-----------------------|----------------|---------------|
| High voltage               |                       |                |               |

- (b) State TWO applications each for HVDC and HVAC. [4 marks]
- (c) With an appropriate diagram, design a cascaded transformer capable of generating 300 kV from THREE units of transformer rated at 100 kV each. Clearly explain the connection of the windings and the role of each component in the system. [13 marks]
- (d) An impulse generator has five stages with each capacitor rated for  $0.2 \mu\text{F}$  and 125 kV. The load capacitor available is 1000 pF. Given that the series and damping resistance is  $400 \Omega$  and  $3 \text{ k}\Omega$  respectively, evaluate the front time and tail time of the generator. [5 marks]

**Question 2**

- (a) The basis of testing high voltage equipment is primarily formed by measurement of high voltage be it DC, AC or Impulse. State THREE main considerations which should be accounted for when selecting the measurement technique. [3 marks]
- (b) The design of uniform field electrode gaps as shown in Figure Q2 is meant to extend the range with uniform electric field which is limited in sphere gaps.
- State TWO advantages of a uniform field gap. [2 marks]
  - State TWO disadvantages of a uniform field. [2 marks]
  - At  $20^\circ\text{C}$  and 760 mmHg, determine the breakdown voltage of the gap ( $s=10\text{cm}$ ) in Figure Q2b. [3 marks]

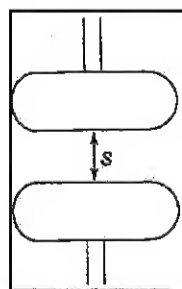


Figure Q2b

**Continued...**

- (c) Test "A" is performed to estimate the 50% breakdown voltage ( $V_{50\%}$ ) of an insulating material. Table Q2c shows the experimental results obtained for a particular impulse test. Note that 'X' represents a breakdown event while 'O' represents a no-breakdown event.

- Identify the name of Test "A". [1 mark]
- Explain the meaning of  $V_{50\%}$ . [2 marks]
- Compute the 50% breakdown voltage and the standard deviation. [12 marks]

Table Q2c

| Voltage (kV) | Test Result |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|--------------|-------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40           |             |   |   |   |   |   |   |   |   | X |   | X |   |   |   |   |
| 38           |             |   |   |   |   |   |   |   | O |   | O |   | X |   |   | X |
| 36           |             |   |   |   |   |   |   | O |   |   |   |   | X |   | O | X |
| 34           |             |   | X |   |   |   | O |   |   |   |   |   |   | O |   | X |
| 32           |             | O |   | X |   | O |   |   |   |   |   |   |   |   |   | O |
| 30           | O           |   |   |   | O |   |   |   |   |   |   |   |   |   |   |   |

### Question 3

- Explain the importance of understanding the dielectric properties of insulation material. [3 marks]
- Define dielectric strength and state FOUR factors which affect the dielectric strength. [6 marks]
- Analyse the space charge effect according to the Streamer Theory used to describe the breakdown in gases. [6 marks]
- Figure Q3d shows the current-field characteristic curve for a hydrocarbon liquid. Analyse the conduction phenomena at Region I, Region II and Region III respectively. [3 marks]

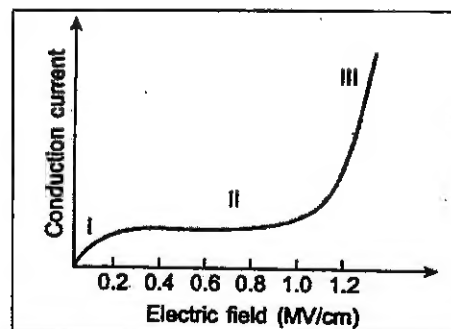


Figure Q3d

Continued...

- (e) Electromechanical breakdown is one of the few breakdown mechanisms of solid insulation.
- (i) Explain electromechanical breakdown. [2 marks]
  - (ii) Estimate the highest electric stress before the breakdown of the insulation materials as shown in Table Q3e. [5 marks]

Table Q3e

| Material | Young Modulus | Relative permittivity |
|----------|---------------|-----------------------|
| A        | 100           | 8                     |
| B        | 150           | 8.5                   |
| C        | 200           | 9                     |
| D        | 300           | 10                    |

**Question 4**

- (a) Explain the term “insulation coordination”. [3 marks]
- (b) Describe the difference between self-restoring and non-self-restoring insulation. [4 marks]
- (c) Describe the differences between Basic Lightning Impulse Insulation Level (BIL) and Basic Switching Impulse Insulation Level (BSL). Then, explain how they affect the design of power system network. [10 marks]
- (d) State the three requirements which have to be satisfied to achieve the best coordination between insulation levels in a station and the preceding line. [3 marks]
- (e) Identify THREE factors which should be considered when deciding the margin that should exist between the BIL of the insulation to be protected and the protective level. State the typical margin for BIL and BSL respectively when diverter is used. [5 marks]

**End of Paper.**



